"The staircase has no supply of air whatever, when the doors below are shut, except the small amount that may enter by leakage there; but sixteen doors on the different floors, as well as the basement, may all draw more or less upon the passage and stairs when there are many fires kindled, and no windows opened for a supply, in consequence of the state of the weather. The result is that one or more doors are opened on every floor to derive some benefit from the atmosphere in the staircase, and the lower floors discharge their vitiated air, which ascends and oppresses the occupants of the upper floors. Some of the chimneys overpower others, drawing down smoke which pervades the staircase. The occupants are forced in self-defence to shut their doors and open their windows, till the cure becomes worse than the remedy, when they again return to their previous position, alternating between these opposite evils so long as they do not choose to suffer quietly the inconveniences that result from their unventilated dwellings."

The first remedy for a great portion of these evils, our author suggests, is the very sensible one of supplying the entry and stairway with a current of fresh air, warmed in winter by a stove in the lower hall, by which simple measure the comfort and health of the occupants would be increased more than by any other that could be mentioned.

With plain and practical suggestions like this, adapted to almost every kind of inhabited building, this volume abounds. The proper construction and arrangement of drains and sewers, and of water-closets, the methods of avoiding the effects of noxious gases from manufactories, "*external ventilation,*" including the rules which should govern in the choice of a site for a dwelling, these and many other cognate matters are well and clearly discussed, and cannot fail to impart instruction to all who desire it.

J. H. G.

ART. XIII.—*Leçons sur la Physiologie et la Pathologie du Système Nerveux.* Par M. CLAUDE BERNARD, Membre de l'Institut, Professeur de Médecine au College de France, &c. &c. Paris, 1858. 2 vols. 8vo. pp. 560—520.

THESE volumes give an account of M. Bernard's last two courses in the College of France on the Physiology and Pathology of the Nervous System; one delivered in the winter term of 1856-57, the succeeding one in the spring term of 1857. The subject is so divided that the first volume treats of the general relations of the nerves and the nervous centres, their influence upon nutrition, calorification, and the like, and the manner in which they are affected by galvanism and other external agents; while the second volume is devoted to the study of individual nerves and the special functions of their different branches.

The author commences, as is almost habitual with him, by defining his position in the opening scientific campaign, and by reminding his hearers that "there are, in the development of the sciences, two distinct departments to be cultivated, viz: the discovery of new truths, and the criticism or co-ordination of those which have already been acquired. Among the cultivators of natural science, the one class strive to extend its limits by the introduction of new ideas; while those belonging to the other are more particularly employed in criticizing the discoveries of the first, and bringing them into relation with established opinions."

Bernard has no hesitation in making the avowal that his own position, as conductor of the physiological course at the College of France, places him in the former category. There is no doubt, beside, that his own preference and intellectual tendencies lie in the same direction. It is curious to observe, indeed, in the physiological discussions which have arisen in France within the last ten or fifteen years, that it is almost always his name which appears at the head of new discoveries and innovations; while his statements and doctrines immediately call up a host of critics and investigators to assail or corroborate them, and furnish abundant material for discussion, examination and counter-experiment, almost without end. Striking examples of this are to be seen in the history of the discovery of the formation of liver-sugar; of the influence of the sympathetic nerve on calorification; of the artificial production of diabetes by wounding the fourth ventricle; and of the digestive properties of the pancreatic juice.

The discovery of the formation of liver-sugar alone, ever since it was first announced, in 1848, to the present time, has given rise to almost incessant discussions, which even now are hardly to be considered as terminated; the most important part of the whole doctrine, viz., the exclusively internal origin of the sugar found in the liver, having been formally assailed no longer ago than May, 1857, in a very able and elaborate communication addressed to the French Academy by M. Sanson, of Toulouse. During this period, the objections raised against Bernard's doctrine have been twice made the subject of special investigation by commissions of the French Academy, and although in each instance the objectors (including M. Sanson) failed to make good their statements before the Commissioners of the Academy, and though the reports accordingly sustained Bernard's doctrine so far as the special points under discussion were concerned, still the question is not yet regarded as altogether settled, nor is there any complete unanimity of opinion in respect to its details. So wide is the field of research which has been opened by one discovery, and so abundant the material for investigation which it has afforded.

The great advantage resulting from this system of encroachment and innovation is that, in whatever way the special questions raised by discoverers may be finally answered, the acquisitions of science cannot fail to be largely increased, and its domain enriched by their agitation. Even if it should hereafter be shown, for example, that Bernard was mistaken in supposing his liver-sugar to be actually and exclusively produced in the substance of the hepatic tissue, how many new facts, brought out in connection with this doctrine and in consequence of its discussion, would remain as permanent scientific acquisitions. The constant presence of sugar in the liver during health, and its passage thence into the hepatic blood; the existence of a "glycogenic matter," similar or analogous to starch and dextrine, and its ready conversion into sugar by animal ferments; the occasional passage of sugar into the circulating fluids throughout the body, and its normal existence in the blood and urine during a part of fœtal life; these are all facts of the greatest interest for the physiologist, and which certainly would not have been discovered except for the attention attracted to the entire subject by Bernard's doctrine. Such acquisitions are necessarily evolved from the intellectual fermentation, which is excited in the scientific world by the contact of new ideas and the stimulus of unexpected discovery.

Bernard is quite right, therefore, when he maintains that the path of experimental inquiry, if followed in the right spirit, *must* conduct us to more advanced posts of knowledge, and result necessarily in enlarging our scientific acquirements. So long as we interrogate nature for the information we wish to acquire, and rely solely upon her answers to guide our studies, our labour cannot be lost. For, though we may afterwards be compelled to modify the conclusions drawn from an experiment, the actual results of the experiment itself cannot be modified, but remain good forever. It will always be noticed, in fact, even when we seem to have been deceived in our investigations, that it is only our *interpretation* of the experimental phenomena which was erroneous. The phenomena themselves, if faithfully observed, are never erroneous; and though our interpretation of them may afterwards be altered, the results of the experiment itself must always remain the same, and forever bear an undiminished value.

The principal danger of misinterpreting the results of experiment lies, as every one knows, in a too great devotion to preconceived ideas or favourite theories. This devotion is often an unconscious one on the part of the experimenter; and it is often to be remarked that an author will disclaim for himself any preference whatever as to which side of the question under investigation may prove the correct one, and will profess the most impartial desire to arrive at the truth, while his expressions and his mode of treating the subject indicate plainly how much he is interested in establishing a favourite conclusion. The cause of this mental bias is generally to be found in the fact that the experimenter fears lest an adverse conclusion should destroy the value of previous investigations; and he is naturally unwilling that science should lose the advantage of so much well meant labour, and that its acquisitions, once regarded as fully established, should afterward turn out to be fruitless.

Such fears, however, as we have remarked above, are always unfounded. The acquisitions of science can never be fruitless, whatever be the result of subsequent investigations. Every one who pursues for a series of years any department of investigation, finds that his ideas and theories undergo successive changes with the lapse of time. He views the subject in a different light, and arranges the facts presented to him by nature in a different order and relation. But in substituting new theories for the old, he never loses anything previously acquired; on the contrary, the new view which he is led to adopt, concerning any set of phenomena, is always more comprehensive and satisfactory than the previous one; for it includes the new facts discovered by experiment, as well as those which had been established before.

It is possible, however, for this truth to be so entirely ignored, and the object and purpose of experimentation so thoroughly misconceived, that investigation may be resorted to only as a secondary matter, for the purpose of confirming, or "illustrating," as it is called, scientific doctrines. This was probably the case with the French *savant*, mentioned by Bernard as a "prominent member" of the Academy of Sciences, though "not particularly eminent," he adds, "in experimental physiology." The academician had been engaged in preparing a memoir upon an interesting physiological subject, which he intended to present to his colleagues at their next session. In conversing upon the subject with Magendie, he remarked that he "should very soon be ready to present his paper; for the memoir itself was already finished, and he had *nothing more to do but to perform the experiments.*"

Bernard gives, in his first chapter, some very judicious directions with regard to what he calls the "art of experimentation;" that is, the manner in which experiments should be arranged and their results compared, the principles upon which they should be contrived, and the care which is requisite in fixing and regulating their conditions. We shall leave this part of the subject, however, and pass immediately to the consideration of a few of the most important topics treated of in the body of the work.

A very prominent place is given, in the early part of the memoir, to the study of the *recurrent sensibility* of the spinal and cranial nerves. As the history of this subject is somewhat remarkable in many respects, and as the author regards the property of recurrent sensibility as affording very important indications in regard to the classification of nerves, it may be considered as one of the most interesting topics treated in the present volumes.

It is well known, that of the two roots by which each spinal nerve takes its origin from the spinal cord, one is motor and the other sensitive in its nature and properties. The anterior root is especially devoted to the function of exciting contraction in the parts to which the nerve is distributed, and has no relation with the sensibility of these parts; while the posterior root is incapable of exciting motion, by any direct influence, and has, instead, the power of conveying sensation from the parts in relation with its terminal branches.

If these roots, accordingly, be separately divided, the function of sensation or of motion will be abolished, according as the injury has been inflicted on the fibres of the first or the second set. If the anterior root be divided, the corresponding part of the body is paralyzed of motion, but retains its sensibility; if the section be made of the posterior root alone, the sensibility is lost, but the power of motion remains unaffected.

The properties exhibited by the nervous roots themselves, when directly experimented on, correspond with the above functions intrusted to them. If the anterior root alone be irritated, by pricking or by the galvanic current, a convulsive movement ensues; if the posterior root be similarly irritated, a painful sensation is produced, but no movements follow, excepting those of a reflex nature.

Furthermore, if the anterior root be divided, an irritation applied to its *detached* extremity (or that which is separated from the spinal cord) produces instant convulsions, but if applied to its *attached* extremity (or that remaining in connection with the spinal cord), no result follows; since the nerve conveys the motor influence by a direct course to the muscle, and must, therefore, in order to produce any effect, be still connected with it by continuity of fibre. If the posterior root be divided, however, an irritation applied to its *detached* extremity is without effect; but, applied to its *attached* portion, is instantly followed by a painful sensation.

These are the properties of the anterior and posterior nervous roots, demonstrable by direct experiment, which first attracted the attention of investigators, and led them to discover the characteristic functions of the two roots, now so well established. Another property, however, was early found to reside in the nervous system, which interfered somewhat with the completeness of these results, at least so far as regards the posterior roots, viz: the *reflex action* of the spinal cord. For, though irritation of the posterior roots has no direct influence on the muscles, yet, in point of fact, if these roots be irritated, in the living or recently-killed animal, muscular contraction is frequently excited in consequence. This muscular contraction, however, following irritation of the posterior roots, is shown to be indirect or "reflex" in its nature, by the two following facts. First, if the posterior root be previously divided, no muscular contraction is ever produced by irritation of its *detached* portion, or that still connected with the muscle, but only when the irritation is applied to its *attached* extremity. The motor influence, accordingly, such as it is, is not conveyed in this case directly from the nerve to the muscle, but reaches the latter only by first passing through the spinal cord. Secondly, if, after performing the above experiment, the anterior root be divided, the posterior will then be found to have lost all power to excite contraction, which ever part of it be subjected to irritation. It is only, therefore, through the medium of the anterior roots that the posterior may sometimes give rise, when irritated, to movements of a reflex nature.

A corresponding class of phenomena, connected with the anterior roots, constitutes the property known as the *recurrent sensibility of the spinal nerves.* It has been found that the anterior roots, when irritated in the living animal, sometimes give evident indications of sensibility. This sensibility is much less acute than that of the posterior roots, but it is still asserted, by various observers, to be occasionally so well marked as to leave no doubt of its existence. Like the reflex motor action of the posterior roots, however, this sensibility is not direct, but indirect, in the manner of its production. For, if the anterior root be first divided, it is the *detached* extremity which remains sensitive, the attached portion being then completely insensible. Furthermore, if the posterior root be divided, the anterior is found to have lost the sensibility which it previously manifested.

The sensibility of the anterior root, therefore, depends upon the existence of sensitive fibres, coming from the posterior root, which join the nerve at the junction of the two roots, and then retrace their course, along the anterior root, toward the spinal cord, in a reversed or "recurrent," direction. These fibres have never been traced by the scalpel, and probably can never be followed out from their commencement to their termination, owing to the mechanical difficulties in the way of such a demonstration ; but the above phenomena would seem to leave no doubt as to their actual existence.

The occasional sensibility of the anterior roots of the spinal nerves was noticed by Magendie as early as 1822 ; though it does not appear that the indirect or recurrent nature of this sensibility was recognized until the year 1839. At that time, both Magendie and Longet found that the sensibility of the anterior roots, when it existed, could be made to disappear by dividing the posterior roots, and they therefore regarded it as an indirect sensibility, derived from the fibres of the latter. Longet, indeed, claimed this discovery as his own, and maintained that it was he who, after observing the phenomenon, communicated it to Magendie.

Both observers, however, subsequently failed to reproduce the experiments with their previous results. The anterior roots, when exposed in the living animal, always, subsequently to the experiments of 1839, appeared completely insensible; and this was the case in so many repetitions, that the existence of a recurrent sensibility was practically given up by nearly all physiologists, and particularly by Longet himself. In his *Treatise on Physiology,* published in 1850,[1] Longet repeatedly, and in the most explicit manner, declares the anterior roots of the spinal nerves to be "*completely insensible* to mechanical irritations of every kind ;" and speaks of his earlier experiments, performed in 1839, and which gave a different result, as wanting in confirmation, and insufficient in their conclusions.

Bernard, however, who was also present at the experiments of 1839, could not persuade himself to abandon the facts observed, whatever difficulties might exist in the way of adopting the conclusions which had been derived from them. As he himself expresses it, he "had been a witness of these facts; he had seen them and touched them; and, notwithstanding that, in the latter experiments of Magendie, the recurrent sensibility of the anterior roots was no longer to be found, he could not on that account ignore the existence of what he had seen before."

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[1] Traité de Physiologie, par F. A. Longet, Paris. 1850.

The manner in which Bernard was again led to discover the recurrent sensibility, illustrates very forcibly the care which it is necessary to take in regulating the conditions of a physiological experiment, if we wish to obtain from it uniform results.

> "I recollected," he says, "that in 1839, at which time I attended the course of Magendie, that all the preparations for the experiment were made in the mornings, and that it was only afterward, during the demonstrations in the amphitheatre, and when the animal had been allowed to repose, that the experiment was tried, and the anterior roots gave signs of sensibility. In the subsequent trials, however, the anterior roots were subjected to irritation immediately after having been exposed to view, and they were then found to be insensible. I had even supposed this promptitude in conducting the experiment to be a condition favourable to success. But after further reflection upon the condition of the animals in which I had before seen the recurrent sensibility to exist, the opposite condition appeared to be the reason of the phenomena which were observed; for, in those instances, the animal had been left for several hours in repose after the preparations for the experiment were made, and this, by allowing him to recover from the fatigue of the operation, must have brought back the nervous phenomena, more or less completely, to their normal condition."

From 1841 to 1846, accordingly, all attempts to demonstrate anew the existence of recurrent sensibility were without success. But afterward, by modifying and varying the conditions of the experiment, Bernard obtained a different result. He found, as above intimated, that a certain period of repose was necessary to enable the animal to recover from the immediate effects of the severe operation of opening the spinal canal, the loss of blood, the cooling of the spinal cord from contact with the atmosphere, &c. &c. He found, in certain instances, that where the operation had been long and difficult, and had been accompanied by a considerable hemorrhage, not only were the anterior spinal roots immediately afterward insensible to irritation, but the facial nerve, which every one knows to possess a certain degree of sensibility, was also insensible at the same time, owing to the partially exhausted and inexcitable condition of the entire nervous system. It was also found necessary to make only a small opening in the spinal canal, just sufficient to expose the roots of the nerves, and not large enough to uncover the entire thickness of the cord itself. All these conditions, however, being fulfilled, a vigorous and well-fed animal being selected for the experiment, a small opening being made in the spinal canal, by a rapid operation, without much hemorrhage, and the animal then allowed to remain at rest for an hour or two, the anterior roots nearly always showed themselves sensitive to mechanical irritation. In this way, Bernard has again demonstrated, since 1846, the recurrent sensibility of the anterior roots, which, for a certain interval, had been a lost fact to science.

It is worthy of remark, however, that Longet still adheres to his belief in the non-existence of what he calls the "pretended recurrent sensibility" of the anterior spinal roots. In the second volume of his Treatise on Physiology, above alluded to (Part II. p. 274), he speaks of this subject as follows:—

> "If the recurrent sensibility of the anterior spinal roots should be regarded as real, I might still insist, as in 1839, upon my right to its discovery; since I was the first who, at that period, directed the attention of physiologists to the extinction of this sensibility which follows division of the corresponding posterior root. But since then, in many hundreds of experiments, *whether I removed one, two, or several of the vertebral arches*, or *whether I allowed my animals to repose or not, after the preliminary operation*, I never observed, in any instance, the pretended recurrent sensibility of the anterior roots; and I have, therefore, been led to abandon my old opinion, which Magendie has recently (1847) again brought forward as the expression of the truth. I nevertheless continue to place full confidence in the later experiments by which I demonstrated the constant and absolute insensibility of the anterior spinal roots and the anterior columns of the spinal cord."

Longet even intimates (page 10 of same volume) that the experimenters who differ with him on this point may have been misled by a faulty method of operating.

> "I said," he remarks, "that I had constantly found the anterior roots, when in a condition of integrity, to be *completely insensible* to mechanical irritations of every kind; and that, on the other hand, the posterior roots had always shown themselves extremely sensitive. But I have sometimes found in the dog, as well as in the human subject, three distinct branches of origin for one lumbar or sacral nerve, running parallel with each other in the spinal canal; two of them belonging to the posterior root, and the third being the anterior root. This seems an important fact to remember, since, when meaning to seize with the forceps the anterior root, one might lay hold of that division of the posterior root which lies in front of the other, in which case the signs of a very acute sensibility would not fail to be manifested. It is essential, therefore, to guard against this source of error, which has not heretofore been noticed, and which is undoubtedly the reason why the anterior roots have been thought to exhibit sensibility."

Bernard, nevertheless, actually exhibited with success the presence of recurrent sensibility in the anterior spinal root, if we are to judge from the context (Vol. I., Lecture 4th, p. 73); and he gives also the following rules, which should be observed in order to insure success in the experiment.

I. The animals selected for operation should be young, vigorous, and well fed.

II. When the animal has not been exhausted or enfeebled by the operation, recurrent sensibility may be exhibited by the anterior roots immediately afterward.

III. But if the animal have become exhausted during the operation, which is most frequently the case, the anterior roots, examined immediately afterward, may appear completely insensible. Then, if the wound be closed by sutures, and the spinal cord covered with integument, by waiting a certain time for the animal to recover his strength, the recurrent sensibility becomes re-established.

IV. The preferable mode of operating consists in opening only one lateral half of the spinal column, in such a manner as to expose one or two nervous roots as far as the ganglion. In this way, the spinal cord is less liable to be affected by cooling; and

V. The anterior roots selected for experiment should be those of the largest size.

Such is the history of opinion on this singular property of the anterior spinal roots. In the opinion of Bernard, it is of great importance, as completing the physiological union between the two roots, motor and sensitive, of the spinal nerves. These roots have opposite properties and functions, but they are still intimately associated, and are necessary to each other's perfect functional activity. The sensitive parts cannot give us complete information with regard to any foreign body, unless they are properly applied and adapted to it by the aid of the muscles; and the muscles cannot contract with certainty and efficiency, unless sensibility is also present, to enable us to appreciate the direction and force of their movements. As the posterior roots, furthermore, are connected with the anterior by the property of reflex action, so the anterior are connected with the posterior by their recurrent sensibility.

Bernard even assumes—somewhat arbitrarily, as we think—that the existence and source of recurrent sensibility in a motor nerve indicate the sensitive roots with which that nerve is associated to form a complete nervous pair; that is, if there be any doubt to which pair of nerves a motor branch belongs, he ascertains from which of the posterior roots it derives its recurrent sensibility, and then regards it as anatomically a branch of that nerve alone. This is undoubtedly allowable in the case of the spinal nerves, where the anterior and posterior roots are all arranged in regular pairs; but its application as a constant rule to the cranial nerves, where there are great variations in the anatomical arrangement, seems of doubtful propriety.

The author treats at considerable length (Chapters VIII., IX., and X.) of the effects produced on the nerves by the stimulus of galvano-electricity; the special influence of the direct and inverse currents, and of the continuous and interrupted currents; and of the differences in reaction, under the electrical stimulus, of motor, sensitive, and mixed nervous filaments. All these details, however, though useful for the experimenter who devotes himself to that particular field, possess but little general interest, and really throw little or no light on the true physiological properties of the nervous fibre. They provide us with the means of more accurate investigation, but are not in themselves particularly valuable or interesting, as a separate class of phenomena.

In the chapter devoted to the properties and function of the spinal cord, Bernard sustains the doctrines promulgated of late years by Brown-Séquard, as to the transmission of sensitive impressions in a crossed direction, the production of hyperæsthesia by section of a lateral half of the cord, and the part taken by the gray matter as a conductor of sensibility. The anterior as well as the posterior columns are sensitive to mechanical irritation, provided the same precautions be observed which are necessary in demonstrating the recurrent sensibility of the anterior roots. The sensibility of the anterior columns is, in fact, a recurrent sensibility, and can be made to disappear, over a limited space, by dividing either the anterior root originating from the cord at that part, or the corresponding posterior root. Section of a lateral half of the cord is followed by an exaggeration of sensibility in the corresponding side of the body below the point of section, and a diminution of sensibility on the opposite side. Finally, after section of the right lateral half of the spinal cord, if the anterior, lateral, and posterior columns of white substance on the left side be also divided, leaving only the gray substance entire, sensibility still persists in the right side of the body below the point of section.

Sensitive impressions are therefore transmitted, in the spinal cord, through the medium of the gray matter, and in a crossed direction; those coming from the right side of the body passing by the left half of the cord, and those coming from the left side of the body by the right half of the cord.

The exaggeration of sensibility after division of a lateral half of the cord, though a phenomenon very difficult of explanation, seems at the present day to be perfectly well established. It undoubtedly accounts for another singular fact, frequently noticed by experimenters, viz., that the phenomena of reflex action of the spinal cord are usually much more energetic after the decapitation of the animal than any movements of a similar nature which we know to take place during life. This increased activity is probably due to an exaggeration of sensibility consequent upon section of the cerebro-spinal axis; only in this case the sensibility is an unconscious one, and produces no other movements than those of a reflex character.

In the second volume the author takes up in succession the different cranial nerves, and examines their properties, their functions, the effect of their division in various parts of their course, the nature and destination of their various branches, &c. &c. The peculiar alteration and destruction of the eyeball, after section of the fifth pair within the cranium, is dwelt upon at length, and various instances are related of an alteration of the sense of taste, dependent on paralysis of the facial nerve in the human subject. Bernard has also demonstrated a similar alteration of the taste in the dog, after division of the facial nerve within the skull. The effects of division of the pneumogastric, upon the pharynx, larynx, œsophagus, lungs, heart, stomach, &c., are also described in detail.

The chapter devoted to the discussion of the *spinal accessory* is principally a reproduction of the elaborate monograph upon this nerve published by the author in 1851. Some years before, Bischoff had published a memoir, in which he maintained the opinion that the spinal accessory was to be regarded as bearing the same relation to the pneumogastric, that the anterior or motor root of a spinal nerve bears to its posterior or sensitive root; in other words, that the spinal accessory and pneumogastric are associated with each other as motor and sensitive roots, forming by their inosculation a complete physiological pair, like each one of the spinal nerves.

This was soon after the discovery of the distinctive properties of the anterior and posterior spinal roots had been followed by the brilliant generalizations of the transcendental anatomists, by which the skull was shown to be in reality a continuation of the spinal column, and to be composed of a series of cranial vertebræ, entirely analogous in their connection and relations with the vertebræ of the spinal column.

It was easy to see, also, that the nervous centres, and the nerves originating from them, presented, to a great extent, similar analogies in their different parts; and the cranial nerves were therefore examined, to ascertain how far they could be classified according to the principle which regulated the arrangement of the rest of the cerebro-spinal system. The three nerves of special sense—the olfactory, optic, and auditory—evidently presented no analogy with the spinal nerves proper, either in their functions or their anatomical arrangement. With regard to the others, however, a very striking analogy could easily be seen to exist. The Fifth pair, more particularly—having a small and a large root, shown to be respectively motor and sensitive in their nature, the large root provided with a ganglion (Casserian), and the two afterwards mingling their fibres to form a mixed nerve (inferior maxillary branch)—was evidently to be regarded as constructed upon the same plan as a spinal nerve, presenting only those modifications of detail necessarily connected with the peculiarities in the form of the skull.

It required only a further development of the same ideas, to classify most of the other motor and sensitive cranial nerves—such as the oculo-motorius, facial, glosso-pharyngeal, and sublingual—in a similar manner; and it was the object of Bischoff to complete the above systematic arrangement by including the spinal accessory with the pneumogastric, as forming together the last pair of the true cranial nerves. He sustained this view by declaring the pneumogastric to be exclusively sensitive at its origin, and the spinal accessory to be purely motor. The ganglion of the pneumogastric, situated in the jugular fossa, he compared with the ganglia of the posterior roots of the spinal nerves; while the internal branch of the spinal accessory, joining the pneumogastric below its ganglion, completed, according to his view, the anatomical union of the two roots, making the trunk of the pneumogastric a mixed nerve, containing both motor and sensitive fibres, like the spinal nerves outside the vertebral canal.

The view thus brought forward by Bischoff was received with great favour by anatomists and physiologists. The analogies upon which it was based were, indeed, in many respects so striking, that they could be regarded in no other light than as the expression of actual anatomical relations existing between the two nerves. By following out this idea all the cranial nerves, with the exception of the three nerves of special sense, may be arranged in pairs, like those of the spinal nerves, according to the distribution of their motor and sensitive filaments. All the branches of the fifth pair emanating from the Casserian ganglion supply the region of the face with general sensibility; while the smaller root of the same nerve, together with the facial and the motor nerves of the eyeball, supply the same parts with the power of motion. The sublingual and the glosso-pharyngeal supply respectively the muscles and mucous membrane of the tongue; while the pneumogastric and spinal accessory perform the same office for the various parts to which these nerves are distributed, viz., the muscular and mucous coats of the respiratory passages and upper part of the alimentary canal. The fact that the oculo-motorius, patheticus, external motor, facial and masticatory nerves, pass out from the skull in separate bundles, cannot of itself prevent our regarding them as physiologically the same nerve; since the physiological identity of any motor branches does not depend so much upon their following the same course, as upon their being finally distributed to the same regions. Even the anterior roots of the spinal nerves originate from the spinal cord by many distinct filaments, and are only collected into a single trunk at a certain distance from their point of origin.

The cranial nerves, then, which are similar in their nature to the spinal nerves, may be arranged, if we adopt this view, in three distinct pairs, each consisting of a motor and a sensitive element, as follows:—

	Motor Portion.	Sensitive Portion.	Distributed to
1st Pair	Oculo-motorius. Patheticus. Motor Externus. Facial. Masticatory.	Sensitive branches of "5th Pair."	Face.
2d Pair	Sublingual.	Glosso-pharyngeal.	Tongue.
3d Pair	Spinal Accessory.	Pneumogastric.	Pharynx, larynx, trachea, œsophagus, lungs, and stomach.

The doctrine which regards the spinal accessory as the motor root of the pneumogastric nerve receives a striking confirmation from the fact that if the spinal accessory be divided at its origin, the laryngeal muscles, supplied by a branch of the pneumogastric, are thereby paralyzed to such an extent that the animal loses the power of producing a vocal sound. This singular fact, viz., the loss of voice after section of the two spinal accessories before their junction with the pneumogastrics, was verified by Bischoff in one successful operation, after several failures; and shows conclusively that some, at least, of the motor filaments of the pneumogastric are derived exclusively from the spinal accessory.

Bernard confirms entirely the above fact from the result of his own experiments. Indeed, his success in performing the operation without inflicting serious injury upon the animal, has been so much greater than Bischoff's, that he seems to have at least an equal claim with the German experimenter, to the establishment of the discovery. The earlier operations consisted in cutting down upon the occipito-atlantoidean membrane, dividing it by a transverse incision, and then cutting off the spinal accessory nerves upon each side through this opening. The external wound, however, in this operation was very large and deep, and in order to reach the superior fibres of the spinal accessory it was usually necessary to cut away a part of the occipital bone; a proceeding almost necessarily followed by troublesome and exhausting hemorrhage from the occipital sinuses. The introduction of air into the veins, owing to the opening of the osseous sinuses, was also found to be a frequent cause of death, during the operation, and consequent failure of the experiment.

Bernard, however, contrived an extremely ingenious operation, by which all these difficulties were remedied. It consists in cutting down upon the spinal accessory just as it emerges from the jugular foramen, seizing at the same time both the external and internal branches between the blades of a forceps, and by a steady, continuous traction tearing away the nerve from its roots. The only difficulty in performing this operation consists in the depth of the wound, at the bottom of which the nerve is to be seized and extracted; owing to which the operator may sometimes fail to grasp the internal or anastomotic branch of the spinal accessory, and lay hold only of the external division of the nerve, which is distributed to the muscles of the neck. When both branches, however, are grasped by the forceps and the traction properly made, the roots of the nerve give way at their origins, even down to the lower part of the cervical region of the cord, and the whole nerve comes away as a slender white filament, an inch and a half to two inches long, terminating in a fine, threadlike extremity. The operation is more readily performed on cats than on dogs, owing to the greater density of the fibrous tissues in the latter, in consequence of which the nerve is apt to be broken, in the effort to bring it away at its roots.

This operation, when successful, leaves the animal with a simple and not very extensive wound of the integument and muscles, which involves no injury to any important organ, and which readily heals, leaving the animal in a favourable condition for exhibiting the effects of division of the nerve, uncomplicated by any other affection or mutilation.

We have already mentioned that the principal effect of this operation is a complete and permanent loss of voice, and that it shows conclusively that the internal or anastomotic branch of the spinal accessory supplies to the pneumogastric, and through it to the larynx, all the motor fibres concerned in the production of vocal sounds.

Bernard, however, is nevertheless unwilling to regard the spinal accessory as representing the motor root of a mixed nerve, of which the sensitive root would be the fibres of origin of the pneumogastric. His objections to this view are both anatomical and physiological in their nature. The peculiarities of the anterior roots of the spinal nerves, with which Bischoff would compare the spinal accessory, are the following:—

1. They originate from the antero-lateral columns of the spinal cord.
2. They join the posterior roots beyond the situation of the ganglion belonging to the latter.
3. They form, together with the posterior roots, a mixed nerve, to every part of which they supply motor fibres.

The objections of Bernard to the view advanced by Bischoff begin with the very origin of the nervous filaments.

> "In the first place," he says, "the mode of origin of the spinal accessory is not the same with that of an anterior root. The source of this nerve extends over a very considerable portion of the cord, while each anterior spinal root originates from a very limited point. Furthermore, instead of commencing, like the true anterior roots, from the line of separation between the anterior and lateral columns of the cord, the fibres of origin of the spinal accessory emerge from a part of the cord much further back, and very near, as we shall see, to the posterior column."
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> "Towards the upper part of the neck, the roots of the spinal accessory are comparatively long, and the trunk of the nerve, running along the side of the spinal cord, rests upon the superior surface of the ligamentum denticulatum. As we go further down the neck, however, the roots of the nerve become shorter and shorter, and its trunk is consequently brought nearer the posterior columns, so that in the lower part of the neck it is placed very far back and in the immediate vicinity of the posterior spinal roots."

The mode of union of the spinal accessory with the pneumogastric is also regarded as differing, in an important respect, from that of the anterior and posterior spinal roots.

> "A weighty objection is to be made against the view taken of the anastomosis of the spinal accessory, in its relations with the ganglion of the pneumogastric. It is well known that each anterior spinal root unites with the posterior root a little beyond the intervertebral ganglion belonging to the latter. Most authors, considering the jugular ganglion of the pneumogastric, or that which is seated upon the nerve at the point where it enters the posterior foramen lacerum, as the analogue of the intervertebral ganglion of a posterior spinal root, have thought to sustain their doctrine by relying upon the fact that the spinal accessory unites with the pneumogastric below this ganglion. But in the first place it ought to be shown this ganglion of the pneumogastric is really analogous to the intervertebral ganglion of a posterior spinal root. Now it is easy to demonstrate that the only ganglion which could be compared with those of the posterior roots is that situated on the trunk of the pneumogastric, below its anastomosis with the spinal accessory. This ganglion in certain animals, as the cat and the rabbit, is very visible and distinctly marked, while in the human subject it is represented by a kind of diffused gangliform swelling, to which is given the name of the *plexus gangliformis*, and which was very correctly described by Scarpa. The anastomosis of the spinal accessory differs accordingly from that of the anterior spinal roots, since it really joins the pneumogastric above the ganglion which is analogous to that of a posterior root."

M. Bernard does not intimate what are the anatomical grounds upon which he considers it "easy to demonstrate" that it is the cervical and not the jugular ganglion of the pneumogastric which represents an intervertebral ganglion of the posterior roots. We should have been glad if he had stated the reasons for this opinion more fully; for we cannot say that, in the absence of further explanation, they are very clear. On the contrary, it seems to us that the jugular ganglion of the pneumogastric, occupying the jugular fossa, is much more properly compared with the intervertebral ganglia, situated in the intervertebral foramina, than the cervical ganglion which is altogether outside the skull, particularly as the pneumogastric gives off one of its branches (pharyngeal) above this ganglion, though below the other. The jugular foramen is certainly altogether analogous, in its anatomical relations, with the intervertebral foramina; and it would seem natural, therefore, to regard the ganglia which it contains as analogous to those situated in the latter.

There are other reasons, however, which lead Bernard to decide against the view entertained by Bischoff, as to the analogies of the spinal accessory. He lays a great deal of stress, for example, on the existence and source of the *recurrent sensibility* of a motor nerve, in determining its physiological relation with sensitive roots.

> "We must now examine," he says, "by this new criterion the question of the association of the pneumogastric and the spinal accessory. We wish to know, in a word, whether the spinal accessory be the anterior root of the pneumogastric. For that purpose, we must ascertain whether the recurrent sensibility of the spinal accessory be derived from the pneumogastric, in the same manner as the recurrent sensibility of an anterior spinal root comes from the corresponding posterior root. If the pneumogastric furnish sensibility to the spinal accessory, we shall in that case be justified in saying that it plays the part, toward this nerve, of a posterior root. If the contrary should prove true, then the question must be decided differently; since the essential property which characterizes the association of the two roots of a pair of spinal nerves would not be found to exist between the pneumogastric and the spinal accessory."
>
> "Now I have convinced myself that the recurrent sensibility of the spinal accessory, a property which I have found very distinct and well marked in this nerve, in the dog, the rabbit, and the goat, is not at all diminished by section of the pneumogastric; proof positive that it is not this nerve which furnishes the former with recurrent sensibility. I shall show subsequently that this recurrent sensibility of the spinal accessory is derived from the posterior root of the four upper cervical nerves; so that, according to this view, the spinal accessory should be regarded as a motor root superadded to the anterior roots of the four upper cervical nerves, since its recurrent sensibility is derived from the same source with theirs."

Finally, the physiological properties of the spinal accessory, as a motor nerve, are not such, in the opinion of the author, as to make it, properly speaking, the anterior root of the pneumogastric. It is true that it furnishes some motor fibres to the latter nerve, but not by any means all that it contains, nor even the most important of them. In the inferior laryngeal nerve, for example, a branch of the pneumogastric, the only motor filaments paralyzed by section of the spinal accessory are those concerned in the production of vocal sounds. The respiratory movements of the larynx go on perfectly well afterward, for the motor powers of the pneumogastric concerned in this function are derived from other sources.

The function of the spinal accessory, indeed, as connected with respiration, is a very curious one, if M. Bernard's views be correct; and we see no reason why they should not be admitted, in this particular, to be in accordance with all the known facts.

Sir Charles Bell considered the spinal accessory as an assistant in the movements of respiration, as complementary to the intercostals and diaphragm, and as calling the sterno-mastoid and trapezius into play when unusual force is required to expand the chest, as in laboured respiration. It seems, however, according to Bernard, that though this nerve be really connected with the respiratory function, the relation between the two is somewhat different from that stated above. Its influence is, indeed, antagonistic rather than favourable to the movements of inspiration. In the larynx, for example, we know that the spinal accessory presides over the formation of vocal sounds. Now these sounds cannot be made during inspiration. They require the close approximation of the vocal chords, and a prolonged, sustained, and unusually forcible expiration, in order to produce the vibration in the larynx necessary to their formation. While the voice is in operation, therefore, breathing is temporarily suspended; and it is suspended by the action of the same nerve which produces, through its motor influence, the vocal sounds.

Such is the function of the internal or anastomotic branch of the spinal accessory.

Again, respiration is suspended in all those prolonged and violent muscular efforts which require the spine and thorax to be firmly fixed, as a point of support to the limbs and muscles of the trunk. A free inspiration cannot be made, as we may very easily convince ourselves, unless these parts be in a certain state of relaxation; and the instant any strong muscular effort is to be made, respiration is instinctively suspended. Now the sterno-mastoid and trapezius muscles, instead of acting, when under the direction of the spinal accessory, to increase the respiratory effort, are stimulated on the contrary to fix the chest and shoulder in an immovable position, and put a stop to respiration while the unusual muscular exertion continues. This is the function, according to M. Bernard, of the external or muscular branch of this nerve.

With regard to the analogical relations of the two nerves under discussion, it is a matter of less importance to classify them in a regular order, either together or separately, than that we should know all their peculiarities, and in what particulars they resemble or differ from the other nerves originating from the cerebro-spinal axis. All the cranial nerves present certain modifications in their course and distribution, by which they vary more or less from the regular type of the spinal nerves. These modifications they present in common with the nervous centres of this part and the cranial bones which inclose them. If it is not necessary, therefore, to insist upon absolute coincidence in every anatomical detail, in order to justify a general analogy between these nerves and the regular pairs of anterior and posterior spinal roots.

Still, the peculiarities of origin and function belonging to the spinal accessory are so marked as to separate that nerve, more widely than most others, from the regular type of anterior spinal roots. It is doubtful, indeed, whether that portion which originates from the spinal cord in the cervical region should not be separated physiologically, as it is separated anatomically (by the posterior cerebellar artery), from that portion originating from the medulla oblongata; particularly as experiment shows that the latter portion alone furnishes the internal or anastomotic branch, while the cervical portion is probably destined altogether for the external or muscular branch. The function of the spinal accessory, at least so far as it is distributed to the larynx, is undoubtedly, also, one of a peculiar and special nature. Its action in exciting the movements of the laryngeal muscles, and the modulation of the voice, is beyond question a peculiar one, and quite different from the ordinary motor action of a spinal nerve.

One of the strongest reasons, however, against considering the spinal accessory and pneumogastric as representing the motor and sensitive roots of a spinal pair, lies in the extremely peculiar nature of the sensibility belonging to the pneumogastric itself. It is not a nerve endowed with any acute general sensibility. It may often be divided, as Bernard testifies, in the living animal, without eliciting any sign of pain; while in the mixed and sensitive spinal nerves, and even more especially in the fifth pair of cranial nerves, a mere touch will produce the most acute suffering. It is a special sensibility, connected with the functions of the lungs and the stomach, which is confided to the pneumogastric, and not the ordinary sensibility characteristic of the spinal nerves. We believe, therefore, that the real analogies of the case would be best satisfied by withdrawing both the pneumogastric and the spinal accessory from the general category of the cranial and spinal nerves, as we have already withdrawn the nerves of special sense, and by considering them as a motor and sensitive pair, differing from the others in the essential nature of the function intrusted to them, as well as in certain details of anatomical distribution.

If we still wish to classify the remaining cranial nerves in a regular series, we can do so by slightly modifying the original plan, and by making, at the same time, four pairs of cranial nerves instead of three; an arrangement more in harmony with the requirements of transcendental anatomy, as they are at present generally understood. By this plan, the pneumogastric and spinal accessory are left out of the list altogether, as being nerves of a special nature and destination. The three sensitive branches of the trigeminus are regarded as distinct nerves, distributed to separate regions of the face; and the glosso-pharyngeal constitutes the sensitive portion of the fourth and last pair. The list of cranial nerves would then be arranged as follows:—

	Motor portion.	Sensitive portion.	Distributed to
1st Pair	Oculo-motorius. Patheticus. Motor externus.	Ophthalmic branch of "5th pair."	Upper facial region.
2d Pair	Facial.	Superior maxillary branch of "5th pair."	Middle facial region.
3d Pair	Masticatory.	Inferior maxillary branch of "5th pair."	Lower facial region.
4th Pair	Sublingual.	Glosso-pharyngeal.	Tongue and fauces.

In the chapter devoted to the study of the pneumogastric, the author insists upon the peculiar character of the sensibility of this nerve, and upon its want of general sensibility. This insensibility of the nerve to ordinary painful sensations is sometimes complete; and when the pneumogastric shows signs of sensibility they are "nearly always of an obtuse character." The probable cause of the difference in this respect, shown by the nerve in different instances, is thus given by the author:—

> "I have often," he says, "experimented upon dogs, in order to ascertain the conditions regulating the sensibility or insensibility evinced by the pneumogastric. I have not yet succeeded in arriving at a perfectly satisfactory explanation of all the phenomena observed; yet it has seemed to me, judging from the greater number of instances, that the pneumogastric is insensible in dogs while fasting, but sensitive during digestion. At the same time, I am far from offering this statement as the expression of an established fact. At all events, there is some modification of the sensibility in these cases—dependent, no doubt, on the special nature of the nerve—which demonstrates plainly that, in this respect, the comparison which has been drawn between the pneumogastric and a posterior spinal root, is an incorrect one."

In the remaining portions of the work, devoted to the history of the pneumogastric and the great sympathetic, there are many interesting details of experiments, though we do not find here anything particularly novel in the statements presented. The effects of dividing the different branches of the pneumogastric, as exerted upon the larynx, the lungs, the heart, and the stomach, are fully discussed, and the different modes of death in these experiments explained, so far as they have yet been successfully investigated.

The author describes, also, the increase of animal temperature produced in the head and face after dividing the sympathetic nerve in the neck; and maintains, in opposition to Brown-Séquard and some others, that this effect is not due to a mere accumulation of blood by paralysis and distension of the vessels. He regards the increase of temperature, in a word, as an active and not a passive phenomenon; similar to the engorgement which takes place in a glandular organ, when, from a quiescent state, it passes suddenly into a condition of active secretion. This opinion has been maintained before, by relying upon the fact that an artificial stasis of the blood induces rather a diminution than an increase of temperature. If the veins coming from the ear of a rabbit, for example, be tied so as to arrest the return of blood, and confine it in the vessels of the part, the organ grows cooler as stasis becomes fully established. It may be very properly objected to this experiment, however, that though the quantity of blood *contained in* the vessels of the parts is thereby increased, the quantity actually *flowing through them* is diminished, and we cannot expect the phenomena of nutrition and calorification to be intensified when the nutritive fluid is prevented from arriving at the organ by the same means which prevents its departure.

The following experiment related by Bernard, however, is not, as he thinks, open to any such objection as the above, and leads to the same conclusion in a more satisfactory manner. He first ties the veins coming from *both ears* of a rabbit; and after the stasis of the blood, and consequent cooling of the parts on both sides, have become fully established, he divides the great sympathetic, on one side, in the middle of the neck. The immediate effect of this operation is a rise in temperature on the corresponding side, and, as both sides are in the same condition as to accumulation of blood, the rise of temperature in this case is thought to be necessarily due to some other cause, operating as an active stimulus to the tissues or the capillary bloodvessels.

It must be acknowledged that the nature and functions of the sympathetic are still shrouded in the greatest obscurity; and the difficulty of isolating it from surrounding parts, without inflicting extensive mutilations upon the animal, will undoubtedly be, for a long time, a serious obstacle in the way of experiments on this part of the nervous system. Its numerous ganglia, scattered everywhere at short intervals throughout its course, make it difficult, also, to determine the true direction of any particular set of its nervous filaments; while it reacts so sluggishly to all artificial stimulus, that direct experiment has so far produced very unsatisfactory results. Bernard, however, gives a very complete account of all that has been ascertained in regard to it up to the present time. He finishes the subject with some considerations as to the effect of dividing the sympathetic, and of wounding certain parts of the medulla oblongata and spinal cord, in stimulating and modifying certain of the secretions. J. C. D.